Open Burning/Open Detonation of Explosives: Contamination & Cost

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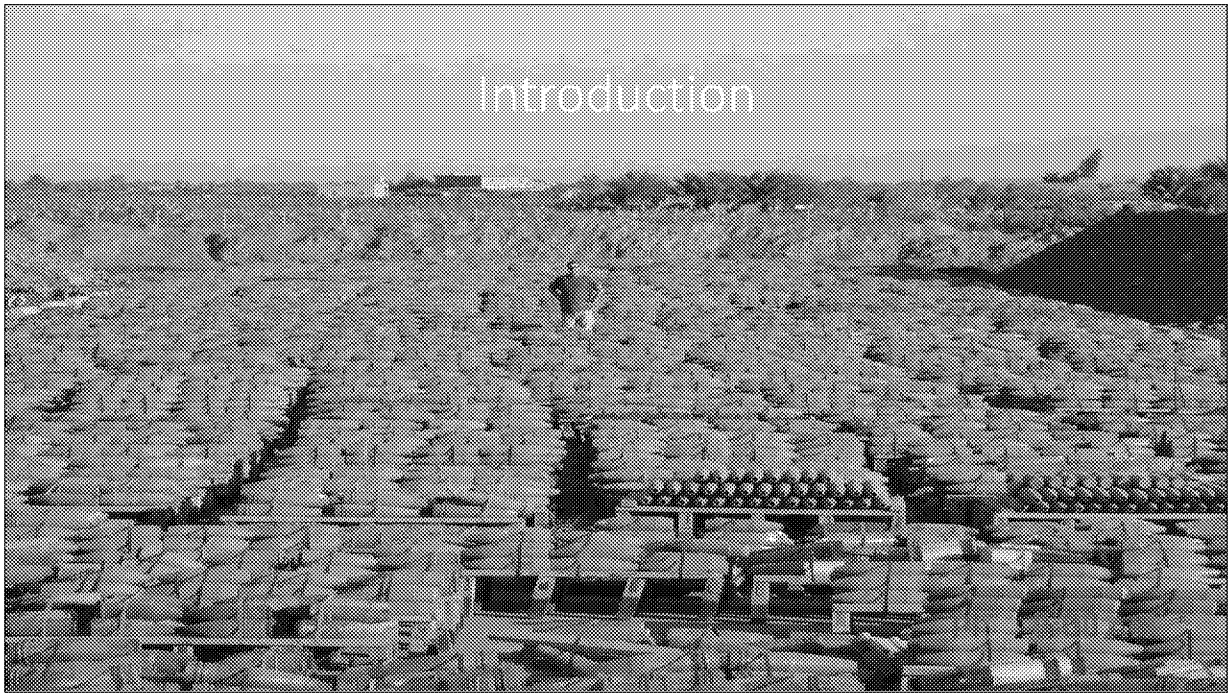
Evaluated data is available on the G:\Share\Drive. The folder is titled "MLipresummerResearch"

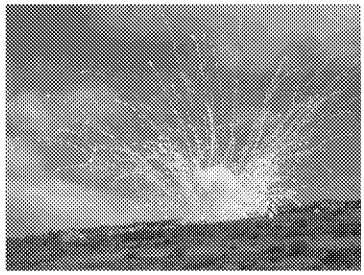
Agenda

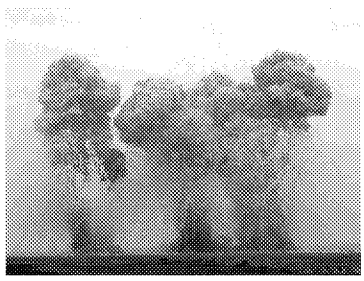
- Introduction
- Background/Task
- Methodology
- 2014 Summer Research-Jordan Moore
- 2015 Summer Research
  - Cost/Remedy
  - Contamination
- Conclusion
  - Acknowledgements
  - Bibliography


Introduction

Background: The Problem

- Resource Conservation and Recovery Act (RCRA) regulations allow facilities to open burn/detonate energetic hazardous waste with virtually no emission controls
- In comparison, incineration of hazardous waste requires compliance with stringent emission standards and thus use of "state of the art" air pollution control devices
- There are a large number of city/state/federal entities open burning confiscated fireworks with no controls





Background – What is ORCR's Explosives Team Doing About This?

- Proving open burning/open detonation (OB/OD) is an uncontrolled, dirty technology, resulting in extensive contamination and VERY expensive cleanups
- Showing cleaner and safer alternative technologies exist
  - Mobile treatment devices with state of the art emission controls
- End goal is to prohibit OB/OD unless there is no reasonably available alternative technology

What Was I Asked To Do To Support This Effort?

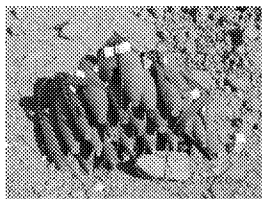
- Continue researching how bad OB/OD really is from a environmental contamination perspective
  - Collecting data from various sources
  - This includes contamination data as well cleanup cost data
- This is critical to support the team's end goal to:
  - 1) Support the effort to discourage OB/OD; and
  - 2) Convince the regulated community that it is cheaper in the long run to use alternatives to OB/OD relative to spending millions in the future to clean up their site
- My research focused on:
  - 1) The extent of environmental pollution caused by OB/OD; and
  - 2) How much it ultimately will cost the companies/government to clean up OB/OD sites

Methodology

- Reviewed and familiarized myself with Jordan Moore's data – 2014 Summer Intern Research
- Used list of 46 OB/OD sites from Jordan to further research cost/remedy information and contamination data
- USEPA Regional Contacts:
  - Harry Craig – EPA Region 10 – Provided info for Umatilla Army Depot, OR
  - Chuck Hendrickson – EPA Region 6 – Provided info for Ft. Wingate, NM

2014 Summer Intern Research – Jordan Moore

- Completed data queries about possible RCRA sites for further research
- Keyword searches under Record of Decision System (RODS) Database for further research
  - ROD database complies official superfund (CERCLA) site decisions
  - Ex: Fireworks, Flares, M6 (and other ammunition), Rocket Propellant, Black Powder, Ammonium Perchlorate
- Contacted EPA Regional Offices



2014 Summer Intern Research – Jordan Moore

- 2005 study by US Government Accountability Office (GAO) – Large proportion of perchlorate contamination in US is from defense related activities and disposal of explosives, fireworks, flares, etc.
- Majority of OB/OD sites analyzed were military: in the RODS Database (76%); in RCRA (56%)
- According to RCRA, 33% currently operating, 57% are clean closing, and 10% are inactive (=100)
- According to RCRA, 83% of the operating units are permitted and 17% are interim status
  - Interim status means they can operate prior to obtaining a RCRA permit provided they comply with the interim status regulations
- Of the 57% OB/OD sites clean closing, 12% so far show waste in place – "A number of large or complex sites seeking to clean close have been unable to do so." [1]

2014 Summer Intern Research – Jordan Moore

- Soil Contamination:
  - High levels of contamination (e.g. 36,045 ppm TNT at Umatilla Army Depot)
  - Can reach distances of 200m
  - "The worst contamination is generally further out, as we can see in the data from Dugway" [1]
    - Dugway Proving Ground is an Army OB/OD site in UT
- Water Contamination:
  - High levels of contamination (e.g. 106,000 µg/kg perchlorate [max level] at US Army/NASA Redstone Arsenal, max storm water concentrations of TNT: 140 µg/L)
- Staggering cleanup costs:
  - Excavating and consolidating contaminated soils
  - Treatment of soils through stabilization/solidification before capping
  - Land Use Controls/Restrictions (costs not reported)


2015 Summer Intern Research

Cost/Remedy

- "There has been cost growth on Operation and Maintenance (O&M) to address groundwater contamination from the mid 1990's to today. O&M will often double in 10 to 20 years."[2]

- Remediation activities at contaminated sites can last for 30+ years (Chemtronics Inc., USN Air Station Cecil Field, **Lawrence Livermore National Lab)

**Building 834: it is projected it will take 400yrs to reach MCLs; Pit 6 Landfill: 30 years; Building 850: 40 years; Pit 7 Complex: 30 years; Building 854: 90 years; Building 832 Canyon: 149 years; with 5 more buildings on site listed as 30 years to reach MCLs

Cost/Remedy

- Expensive cleanup costs
- A number of sites have multiple areas in need of cleanup
- Many sites are continuing the cleanup and monitoring process; costs can be expected to rise at some sites

- **Cleanup costs of 11 sites:**

  (For all 46 sites, I compiled a list of all the alternative remedies considered and their costs)

  - Lawrence Livermore Nat'l Lab (DOE) $626.7m
  - Ft. Wingate, NM $192m
  - Air Force Real Property Agency/ Castle Air Force Base >$150m
  - Idaho Nat'l Eng. Lab (DOE) $48.3m
  - Iowa Army Ammunition Plant $40.3m
  - US Army Garrison/Ft. Wainwright $10.9m
  - Banger Ordnance Disposal *$8.9m
  - Aqua Tech Environmental Inc. (Groce Labs) $4.7m
  - Cecil Field USN Air Station $2.8m
  - Bangor Naval Submarine Base $1.8m
  - US Army/NASA Redstone Arsenal $1.7m

*Cost estimated in ROD for Site A selected remedy was $2.7M (1991 present value cost). Actual remediation costs are projected to be $8.9M. REMEDY HAD COST INCREASE GREATER THAT 50% RELATIVE TO THAT ESTIMATED IN ROD

All cost/remedy info: Extract 1

Region	Superfund / RCRA/Both	Site	ROD DATE	EPA ID	Location	Remedy/Costs	Remedy/Costs cntd.
7	B	Iowa Army Ammunition Plant	9/2/2011	IA7213820445	Middletown, IA	Selected Remedy (Alternative 4-soil & Alternative S3-structures) Alternatives Alternative 1-No Action for Soil -$0 Alternative 2-Land Use Controls for Soil Estimated 30-year Cost: $2,114,700 Estimated Capital Cost: $244,200 Estimated O&M Cost: $1,870,500 Estimated Present Worth Cost: $1,111,100 Alternative 3-Excavation of Depleted Uranium Contaminated Soils with Off-Site Disposal Estimated Capital Cost: $50,295,375 Estimated O&M Cost: $1,251,777 Estimated 30-year Cost: $51,547,151 Estimated Present Worth Cost: $45,985,254 Alternative 4-Excavation of Depleted Uranium Contaminated Soil with Physical Treatment and Off-Site Disposal Estimated Capital Cost: $44,029,169 Estimated O&M Cost: $1,142,864 Estimated 30-year Cost: $45,172,033 Estimated Present Worth Cost: $40,275,497	Alternative S1-No Action for Structures - $0 Alternative S2-Land Use Controls for Structures Estimated Capital Cost: $15,373 Estimated O&M Cost: $233,629 Estimated 30-year Cost: $249,002 Estimated Present Worth Cost: $114,722 Alternative S3-Decontamination/Replacement of Structures Estimated Capital Cost: $30,500 Estimated O&M Cost: $72,461 Estimated 30-year Cost: $102,961 Estimated Present Worth Cost: $58,477

All cost/remedy info: Extract 2

Region	Superfund/ RCRA/Both	Site	ROD DATE	EPA ID	Location	Remedy/Costs	Remedy/Costs cntd.	Remedy/Costs cntd.
9	S	Lawrence Livermore National Lab	7/31/2008	CA2890090002	Tracy, CA	Major components of DOE's cleanup for site 300: -monitoring to determine if cleanup meets regulation for human health and the environment, to measure cleanup progress, evaluate plume migration, and to detect any future releases from the Fit 2, 8, and 9 Landfills or changes in contaminant concentrations in OU 8 release sites that could impact human health or the environment -risk and hazard management -extracting and treating contaminated ground water containing VOCs, TBOS/TKEBS, nitrate, perchlorate, HE compounds, and uranium to meet cleanup standards. -Extracting and treating soil vapor containing VOCs at the Building 834, Building 854, and Building 832 Canyon OUs. -Monitored natural attenuation to reduce VOC and nitrate concentrations and tritium activities in ground water to cleanup standards. -Installing an engineered drainage diversion system at the Fit 7 Complex to hydraulically isolate the contaminant sources in the landfills and underlying bedrock from subsurface water -continue evaluating innovative technologies to expedite cleanup	-No further Action selected in Interim Site-Wide ROD for COCs in surface soil, COCs in subsurface soil/rock, and Non-VOC contaminants of concern. -Although not considered a ground water response or remedial technology, monitoring is included in all alternatives (monitoring network described in ROD) Alternatives - underlined is selected remedy Building 834 (OU 2) -No Action -no costs -Monitoring, Risk and Hazard Management, and Ground Water and Soil Vapor Extraction and Treatment - Total cost based on time to reach MCLs (400 years) is $173.9 million Fit 6 Landfill (OU 3) -No Action - no costs -Monitoring, Risk and Hazard Management, and MNA - Estimated Present Worth Cost $4.5 million based on 30 yrs. High Explosives Process Area (OU 4) -No Action -no costs -Monitoring, Risk and Hazard Management, Ground Water Extraction and Treatment, and Monitored Natural Attenuation Total cost is $179.5 million Building 850 Firing Table -No Action -no costs -Monitoring, Risk and Hazard Management, and MNA - total cost calculated based on time to reach MCLs (40 years) is $17 million Fit 7 Complex (OU 5) -No Action - no costs -Monitoring, Risk and Hazard Management, MNA, Source Control, and Ground Water Extraction and Treatment - Estimated Present Worth Costs (30 yrs.) $10.8 million	Building 854 (OU6) -No Action -no costs -Monitoring, Risk and Hazard Management, Ground Water and Soil Vapor Extraction and Treatment - total cost calculated based on time to reach MCLs (90 years) is $80.3 million Building 832 Canyon (OU 7) -No Action - no costs -Monitoring, Risk and Hazard Management, MNA, and Groundwater and Soil Vapor Extraction and Treatment - the total cost based on time to reach MCLs (140 years) is $157.9 million Building 801 Dry Well and the Fit 8 Landfill (OU 8) -No Action - no costs -Monitoring and Risk and hazard Management - Estimated cost is $0.5 million for 30yrs monitoring at Fit 8 Landfill Building 833 (OU 8) -No Action - no costs -Monitoring and risk and Hazard Management Estimated cost is $0.8 million for 30 yrs. monitoring and exposure control Building 845 Firing Table and Fit 9 Landfill (OU 8) - No Action - no costs -Monitoring and risk and Hazard Management Estimated cost is $0.5 million for 30 yrs. monitoring Building 851 Firing Table (OU 8) -No Action - no costs -Monitoring and Risk and Hazard Management Estimated cost is $0.5 million for 30yrs monitoring Fit 2 Landfill -No Action - no costs -Monitoring and Risk and Hazard Management Estimated cost is $0.5 million for 30 yrs. monitoring

Cost/Remedy

- A number of sites chose cheapest remedy
  - Some appear successful enough, but there are examples where the original remedy chosen has not been successful and cleanup costs increase greatly
    - Air force Real Property Agency/Castle Air Force Base
    - Concord Naval Weapons Station
    - Fort Ord
    - Northside Landfill
  - Institutional (land use) controls remedy in most cases just postpones the ultimate need and costs to clean up

Modified remedy with increased costs extracts

Region	Superfund/ RCRA/Both	Site	ROD DATE	EPA ID	Location	Remedy/Costs
9	S	Concord Naval Weapons Station	5/8/2008	CA7170024528	Concord, CA	The final ROD was signed July 2004 under CERCLA for a presumptive remedy landfill cap at the IR Site 1 landfill. Selected Remedy (presumptive remedy cap and waste consolidation) ~The previous design for the landfill cap resulted in a cost of $2,970,000. The revised RD requires 143,000 cubic yards of imported fill and has a total surface area of 643,000 square feet. The synthetic biotic barrier layer is 543,000 square feet with the area of the geosynthetic liner and the filter fabric (two layers). ~The estimated total cost of construction is $5,250,000 ~The additional estimated cost resulting from the redesign is $2,280,000

Region	Superfund/ RCRA/Both	Site	ROD DATE	EPA ID	Location	Remedy/Costs
9	S	Fort Ord	7/14/2010	CA7210020676	Marina, CA	Selected Remedy -No Further Action for Soil -Groundwater extraction and treatment, to be monitored on a regular basis and adjusted as warranted by the performance data collected during operation ~The cost of the original GWETS in 1988 and annual operations and maintenance costs from 1988 to 1994 was estimated at $942,000. The OU1 ROD estimated the cost of 24 more years of operations and maintenance from 1994 to 2018 to be $950,000. In 2009 dollars, the total cost of construction and operations and maintenance to completion of the remedial action would be approximately $3.2 million (when plume length was believed to be 1/4 mile, not 5/8 mile). ~The construction, operation and maintenance costs through 2009 have been approximately $8.29 million

Contamination

Soil

- Alabama Army Ammunition Plant – up to 24,000 ppm of Lead detected and 26,100 ppm DNT detected (0-1 ft. surface soil)

Table 1B
Concentrations of Contaminants of Concern (COCs) in Soils in Study Areas 2, 10, 17, 19 and 22 at AEAAP Area B (SAIC, Draft Supplemental RI, February 1996)

Study Area	Medium	Analyte	Frequency of Detection	Concentration Detected (ppm)	
				Mean	Maximum
2	Surface Soil 0-1 ft.	2,4-Dinitrotoluene	2/8	3,260	26,100
10	Surface Soil 0-1 ft.	Manganese	3/3	2,090	4,100
17	Surface Soil 0-1 ft.	2,4-Dinitrotoluene	5/7	718	4,000
		Manganese	3/5	1,460	2,400
19	Surface Soil 0-1 ft.	Lead	19/20	2,410	24,000
22	Surface Soil 0-1 ft.	Lead	9/9	1,530	5,020
		Manganese	3/3	891	1,370

Source: Draft Final RI Report, Alabama Army Ammunition Plant Area B Supplemental Remedial Investigation, February 1996, prepared by Science Applications International Corporation (SAIC). Contaminants of Concern from Table 8-55, and Frequencies of Detection and Concentrations from tables in Section 4.

Contamination

(Former) Nebraska Ordnance Plant

- TCE and RDX concentrations exceeded Maximum Contaminant Levels (MCL) in groundwater
- 23 billion gallons or 69,000 acre-feet, underlying approx. 6,000 acres have Contaminants of Concern (COC) concentrations exceeding Final Target Groundwater Cleanup Goals

Site	EPA ID	Groundwater Contamination	Soil Contamination
(Former) Nebraska Ordnance Plant	NE6211890011	"RDX, TNT, and TCE were identified in the groundwater samples. Some of the TCE concentrations exceeded the MCL of 5 µg/L. Additional residences were identified where the TCE concentrations exceeded the MCL or the RDX concentrations exceeded the HA of 2 µg/L." "The OU2 RI identified four groundwater contamination plumes with separate source location identified for each plume. Two of the plumes consist of explosives contaminated groundwater (primarily RDX) and two of the plumes consist of primarily TCE-contaminated groundwater. The plumes overlap in two areas were both TCE and RDX are in the groundwater in the same location. Both the TCE plume with its source at the Atlas Missile Area and the explosives plume with its source at Load Lines 2, 3 and 3 extend past the eastern boundary of the former NOP." "The estimated volume of groundwater with COC concentrations exceeding the Final Target Groundwater Cleanup Goals is approximately 23 billion gallons, or 69,000 acre-feet, underlying approximately 6,000 acres."	"These soils which do not meet the OU1 excavation criteria could potentially act as a source of continuing explosives contamination of groundwater and are referred to subsequently as 'leaching soils', and are addressed by the OU2 remedy...The potential TCE soil contamination is not located in the areas contaminated with explosives." "Locations potentially requiring remedial action were identified as those where solid pieces of TNT were visibly present or where TNT was found in soil at concentrations greater than 2 percent by weight. The areas identified based on these criteria were at three of the load lines and parts of the Burning/Proving Grounds." "ATSDR [1991] concluded that potential human exposure to hazardous substances at the former NOP may result in adverse health effects. It was concluded that the public could be exposed to the explosive compounds RDX and TNT via skin contact or soil ingestion." "The majority of the explosives contamination was detected in shallow soil. At the same locations...explosives compounds were detected at depths of approximately 30 feet below the surface. Explosives contaminant concentrations in the ditches generally decreased downstream from collection sumps. TNT, RDX, and 1,3,5-trinitrobenzene (TNB) were the explosives contaminants most often detected." "PCB-contaminated soil was identified in locations associated with former transformer pads and subsequently removed by the University in 1985 and USACE in 1994 and 1995. Removal of remaining PCB-contamination is ongoing. Unexploded ordnance has not been found on-site, but some internal components of ordnance (booster adapters, fuses, propellants, and bulk TNT) were found and disposed." ...

Contamination

Ft. Wingate Depot

- "Areas ordnance surveys/clearances
  1992-3: 10,582 ordnance items + 160 lb. bulk explosive
  1995: 69 live ordnance items
  1995-98: 27 ordnance items
  1998-99: 340 ordnance items

  Hazardous waste management unit removal (2013-Nov. 2014, ongoing): 5,113 items (Expected to total 18-20,000)

Site	EPA ID	Groundwater Contamination	Surface Water Contamination	Soil Contamination
Fort Wingate Depot, NM	NM62138209 74	"Groundwater energetics contamination - maximum detections in OB/OD wells TNT: 2.5 µg/L 2,4-DNT: 5.1 µg/L 2,6-DNT: 5.1 µg/L 2-amino-4,6-DNT: 2.2 µg/L 4-amino-2,6-DNT: 3.1 µg/L RDX: 250 µg/L Nitrate an N: 27.1 mg/L HMX: 37.2 µg/L Tetryl: 1.1 µg/L Perchlorate: 15 µg/L All from OB/OD groundwater analyses (10/1996-4/2013). Groundwater monitoring system was not complete, and is now shut down for duration of HWMU (Hazardous Waste Management Unit, the regulated current OB/OD Area) removal. " - Chuck Hendrickson; EPA Region 6	"There is no surface water at the site. The site is located in a geological strike valley with an arroyo running through it" - Chuck Hendrickson; EPA Region 6	" We don't have a good set of samples for soil contamination; I do note that parts of the central site area had visible chunks of RDX and TNT scattered across the surface" - Chuck Hendrickson; EPA Region 6

Contamination

Plattsburgh Air Force Base

- Iron, manganese, lead, selenium, and thallium detected above their groundwater ARARs

Site	EPA ID	Groundwater Contamination	Soil Contamination
Plattsburgh Air Force Base	NY4571924774	~"RDX was the only explosive compound detected both in soil and groundwater; its presence is due to past ordnance disposal at the EOD Range. RDX was detected in two groundwater monitoring wells down gradient from this area (MW-26-003 and MW-26-004) at concentrations slightly exceeding the USEPA's Drinking Water Health Advisory value." ~"Two groundwater seep samples collected downslope from these soil samples had iron, manganese, lead, selenium, and thallium detections at concentrations exceeding their respective groundwater ARARs (no other chemicals were detected in the seep samples). The concentrations of iron and selenium in the groundwater sample from MW-26-005 also exceeded their respective groundwater ARARs. The 1999 analytical results indicate that the site may be contributing selenium to groundwater, however, selenium was not detected in any of the 1994 soil or groundwater samples."	~RDX was the only explosive compound detected both in soil and groundwater; its presence is due to past ordnance disposal at the EOD Range. RDX was detected in a soil sample from the former bermed ordnance disposal area at concentrations slightly exceeding the USEPA's Drinking Water Health Advisory value." ~Four metals - antimony, cadmium, chromium, and silver - were detected at concentrations exceeding TBV values in the 1994 soil samples collected in the bermed area. Three metals - copper, selenium, and zinc - were detected at concentrations exceeding TBC values in the 1999 soil samples collected in the 'satellite fill area'. These soil samples were collected down gradient of all SS-026 monitoring wells. "

Contamination

Seneca Army Depot

- NY designates all groundwater as possible source of drinking water
- Iron and manganese detected at levels exceeding State of New York (Class GA) Groundwater Standards
- A total of 32,900 cubic yards (42,188 tons) of material was excavated during the IRA (Interim Removal Action)
- Area of soil contaminated at SEAD-11 was assumed to be 4 acres (16,723m^2)

Site	EPA ID	Groundwater Contamination	Soil Contamination
Seneca Army Depot	NY0213820830-R NY0213820831-R	~"New York designates all groundwater as a possible source of drinking water...the groundwater at SEDA is designated as GA, and thus New York's groundwater standards are ARARs." ~"Groundwater samples collected from the area of SEAD-11 after the completion of the IRA showed the presence of iron and manganese (and total iron plus manganese) at levels that exceeded State of New York GA Groundwater Standards. These metals are both present in the native soils at reasonable levels, and the elevated readings of iron and manganese found in the Depot-wide groundwater are likely associated with turbidity and entrained particles that are contained in the raw groundwater samples." "The Army determined that the disposed materials placed at the landfill represented a potential human health and environmental risk due to the presence of VOCs, cPAHs and metals which were found in the collected soil and groundwater samples. In response...the Army prepared the 'Action Memorandum for Removal Action at SWMU SEAD-11, Revised Final' (Parsons, 2004). "	~"The area of soil contamination at SEAD-11 was assumed to be 4 acres (or 16,723 m^2), the total SEAD-11 area." "Ten pesticides were detected, and one pesticide, 4,4'-DDT, exceeded the TAGM criteria. Soil analytical results showed that two VOCs, acetone and TCE, were detected at concentrations above their respective TAGM criteria. Sixteen SVOCs were found at concentrations above their TAGM values in the soil samples analyzed. Of the 24 metals reported in the soil samples analyzed, 23 of these were found in one or more samples at concentrations above their associated TAGM values. Soil concentrations of particular note in the soil at the landfill include TCE (up to 42 ppm) and lead (up to 7,210 ppm)." "The Army determined that the disposed materials placed at the landfill represented a potential human health and environmental risk due to the presence of VOCs, cPAHs and metals which were found in the collected soil and groundwater samples. In response...the Army prepared the 'Action Memorandum for Removal Action at SWMU SEAD-11, Revised Final' (Parsons, 2004). "

Contamination

US Army/NASA Redstone Arsenal

- Arsenic was detected at concentrations exceeding background values and screening values in overburden groundwater
- Arsenic concentrations in surface soils (0-1 ft.) : maximum of 1,640 mg/kg
- Arsenic concentrations exceeded screening criteria for surface water near capped waste disposal ponds and downstream the industrial sewer outfall from former Plants 5 and 6

Site	EPA ID	Groundwater Contamination	Surface Water Contamination	Soil Contamination
US Army/ NASA Redstone Arsenal	AL72100207 42	Shallow Overburden (Perched Groundwater) "Perched groundwater was found at the Plants 3 and 4 areas and was formed from water supply lines, storm sewers, and steam line condensate discharge. Trichloroethene (TCE) was the volatile organic compound (VOC) most frequently detected above screening criteria. No sources of TCE were found in soils at RSA-122. Three metals (antimony, arsenic, and lead) were detected at concentrations that exceed background values and screening values." Overburden Groundwater "Arsenic is the only metal detected at concentrations that exceed background values and screening values in overburden groundwater. Only the highest concentrations of arsenic is soils have impacted very localized areas of perched groundwater in the shallow subsurface at the sit and overburden groundwater beneath the site. The presence of arsenic in overburden groundwater at a maximum concentration of 1,740 micrograms per liter is contrary to the travel-time analysis. There is evidence that some contaminants have been released directly into the shallow overburden (perched) groundwater (arsenic at 5,490 µg/L) or overburden (arsenic at 1,740 µg/L) groundwater zone and therefore, in some cases, travel distances are essentially zero. The distribution of arsenic, for example, around the Plant 3 and Plant 4 collecting pits suggest that the base of the pit was a release point for arsenic-containing wastes. However, plumes appear to be limited in lateral extent within the unit boundaries."	" Concentrations of arsenic in surface water samples exceeded screening criteria at locations near the capped waste disposal ponds and downstream of the industrial sewer outfall from former Plants 5 and 6 (RSA-122E)."	Subsurface Soil "The majority of arsenic concentrations in surface soils (0 to 1 foot) are present around the off-loading rail spur and arsenious oxide storage silos of the former AT plant (maximum of 1,640 mg/kg), the sump by the AT storage tanks and collecting pits of Plants 3 and 4 (maximum of 641 mg/kg) and blow case pit at the distillation building (Plant 4) associated with RSA-122S; the trench located within the former lewisite reactor building (Plant 5); and the blow case pit associated with the distillation building (Plant 5) associated with RSA-122E. Outfall locations of the former industrial sewer system also exhibit elevated arsenic (maximum of 303 mg/kg) (Table 2). In general, the elevated arsenic concentrations are bounded by sample locations with much lower arsenic concentrations, which suggests that the extent of the most highly contaminated soil has been delineated." Subsurface Soil "As with surface soils, arsenic and mercury were identified as site-related contaminants in subsurface soils at the site. Arsenic concentrations were highest in the area of the former AT plant (2,770 mg/kg at RSA-122S) and near below grade structures (sumps, pits, trenches) associated with Lewisite Plants 3 and 4 (RSA-122S) (Table 2-12 in the RI Report [Shaw, 2007a]). Elevated arsenic concentrations in the shallow subsurface are evident in the area of the industrial sewer outfalls. Concentrations of mercury (maximum of 117 mg/kg) are highest in the area of the collecting pits at Plants 3 and 4 (RSA-112S), with minor concentrations at Plant 5 (RSA-112E) near the collecting pit and manufacturing building (Table 2-9 of the RI Report [Shaw, 2007a])."

Contamination

Aqua Tech Environmental Inc.

- Aluminum, arsenic, cadmium, copper, iron, lead, and mercury all exceeded the residential PRGs and were two times the average concentration detected in background samples

Site	EPA ID	Soil Contamination
Aqua Tech Environmental Inc. (Groce Labs)	SCD058754789	"Aluminum, arsenic, cadmium, copper, iron, lead, and mercury were present in Site soils at concentrations which exceeded the residential PRGs and were greater than two times the average concentration detected in background samples. If the concentrations of the compounds detected in Site soils are compared to the industrial PRGs and twice the average background concentrations, the exceedances are limited to: ~arsenic in 14 of the 103 samples evaluated, 8 on-site and 7 off-site. Five of 8 on-site samples were samples of concrete. The two exposed on-site soil samples with exceedances of the arsenic criteria were from locations 505 and SS-8. The average concentration of arsenic in these samples was 11 mg/kg. The off-site samples which exhibited exceedances of the arsenic criteria were all from soil borings advanced on the property to the north. The average concentration of arsenic in the surface soil (0 to 1 foot bgs) at these locations was 89 mg/kg; ~ copper in the exposed waste in Area 501-09; ~ mercury in 3 of the 103 samples evaluated. The samples of exposed soil which exhibited exceedances were from Areas ERC-01, 501-03, and 501-04. The average concentration of mercury in these exposed soils was 57.2 mg/kg; and, ~ cyanide in all samples which exceeded the residential PRO." "Concentrations of chemicals of concern exceeding the PRGs were limited to the upper 4 feet of the soil horizon. PCE and TCE were the only VOCs detected in soil at concentrations that exceeded the PRGs. Samples from boreholes BH-4 and BH-8 had reported concentrations of PCE of 441 300 mg/kg, respectively. TCE was detected in boring BH-8 at a concentration of 14 mg/kg. Borehole BH-28 was the only borehole in Area 601-02 that contained VOCs in exceedance of their respective PRGs. PCE and TCE were detected at concentrations of 17.1 mg/kg and 21.2 mg/kg, respectively." "In the Process Distillation Area, the upper 8 feet of the borehole contained concentrations of PCE and TCE as high as 320 mg/kg and 1,020 mg/kg, respectively, in exceedance of PRGs. The bottom-sample from BH-18 (9 feet bgs) had reported concentrations of PCE and TCE of 12.1 mg/kg and 15.3 mg/kg, respectively."

Conclusions

- Verified and agree with the 2014 Research/Data – Jordan's
- The cleanup costs of OB/OD sites can be staggering and the O&M costs may double in 10-20 years
  - With some original remedies failing to clear the contamination, there have been instances where the remedy is changed, causing an increase in cleanup costs
- The contamination created from OB/OD is vast and prominent. One example: 16,141 ordnance items removed at Ft. Wingate, NM 1992 up to Nov. 2014.
- Alternatives to OB/OD that better protect the environment and that offer better cost effectiveness must be:
  - Sought after/investigated;
  - Researched/verified; and
  - Most importantly encouraged/required by RCRA permit writers
- EPA must lead this shift in treatment methods.

Acknowledgments

Thank you very much to Michaelle Wilson, Harry Craig (EPA Region 10) and Chuck Hendrickson (EPA Region 6), my fellow interns and all of those who have helped me with this project and have provided great assistance and data.

I would like to especially thank the EDAT team for continuously creating an enjoyable yet productive work atmosphere. Ken Shuster, Ben Lesser, Mike Galbraith, Norma Abdul-Malik and Mike Svizzero all embrace their expertise and share it through their much appreciated advice.

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